Transforming e-Services Evaluation Data into Business Analytics Using Value Models

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Abstract: *The rapidly increasing penetration and use of the Internet, in conjunction with the explosion of various technologies based on it, gave rise to the development of numerous e-services, such as e-business, e-banking, e-government and e-learning ones. The websites providing these e-services collect large amounts of users' activity and evaluation data. It is necessary to transform these data into useful business analytics that allow a better understanding of the strengths and weaknesses of the e-service, the various types of value it generates, and its whole value generation mechanism, and at the same time provide guidance for its improvement and optimization. In this direction this paper proposes and validates a methodology for transforming users' evaluation data into practically useful business analytics, which is founded on well established theoretical frameworks from previous research in the areas of IS evaluation, Technology Acceptance Models (TAM), IS Success Models and e-services. It is based on the definition of a three layers value model of the e-service, which includes its main value dimensions and measures, concerning its efficiency, effectiveness and impact on users' future behavior respectively. This value model is used initially for collecting e-service evaluation data from users and for processing them. From these data are then calculated two classes of business analytics: the average users' ratings for all value measures, dimensions and layers, which allow the identification of strengths and weaknesses of the e-service at various level; and the impacts of first layer value measures (which are 'independent variables) on the second and third layer value ones (which are 'dependent' variables), which allow a better understanding of the value generation mechanism of the e-service and a rational definition of improvement priorities. The proposed methodology has been applied and validated for an e-learning service provided by the National Technical University of Athens (NTUA) to ICT professionals.*

Keywords*: e-service analytics, e-service quality, e-service evaluation, Technology Acceptance Model (TAM), IS Success Models.*

1. Introduction

As Internet penetration and use grows rapidly worldwide, and many new information and communication technologies (ICT) are continuously developed based on it, organizations (in the private as well as in the public sector) are trying to exploit this trend by making large investments for the design, development, delivery and support of various types of e-services, such as e-business, e-banking, e-government and e-learning ones. These e-services aim to offer to their users various electronic resources (e.g. useful data and content) and capabilities to execute electronically various tasks and transactions (e.g. to search for and buy products and services, to conduct transactions with banks and government agencies, to acquire new knowledge and skills) on a daily 24hours basis from their homes or offices. However, despite the high investments that have been made for setting up and running these e-services, for most of them usage is below expectations and users are not satisfied with their quality (e.g. see European Commission, 2008; Sumak et al, 2009), so they need improvements in order to reach higher levels of maturity. At the same time, the websites providing these e-services are usually collecting and storing large amounts of data concerning users' activity (e.g. from which other websites or search engines users

are coming from, which pages they view and for how long, which products they buy, from which pages they are leaving the website, etc.) and also users' evaluation (collected through online evaluation questionnaires). It is of critical importance to transform these data into useful business analytics, which enable a better understanding of the strengths and the weaknesses of the e-service, the types of value it generates for the users and its whole value generation mechanism, and at the same time provide guidance the improvement and optimization of the e-service. Organizations have to exploit those raw data to the highest possible extent and extract from them as much knowledge as possible, since there is a pressing need to improve substantially e-services maturity and quality, and a continuously growing competition in this domain.

In this direction many organizations have started analyzing the enormous amounts of data of their web log files in order to draw conclusions that will assist them in identifying and implementing necessary technical and business adaptations. At the same time a web analytics industry is gradually developed, which includes a growing number of recently emerged firms that can be divided into three categories: (a) providers of web analytics software with extensive data extraction, analysis and reporting functionalities, (b) application service providers (ASPs) who provide web analytics services in a hosted ASP model, which offers the advantages of quicker implementation and lower costs, and (c) providers of benchmarking services, which allow firms to learn from other competitive websites (Park, Kim and Koh, 2010). We can clearly observe the gradual development of the concept of the 'web analytics services' (WAS) provider, who aggregates and analyzes weblog data about the online activities of the users of client organization's website, and produces analytical reports that facilitate a better understanding and interpretation of them, and also provide directions for the necessary improvement interventions. The development of methodologies for more sophisticated analysis of various types of users' activity and evaluation data, so that more knowledge can be generated from them, will be very useful both for the WAS and their client organizations, and will contribute to the growth of this new industry and the maturity of the e-services.

In this direction this paper proposes and validates a methodology for transforming e-service users' evaluation data into useful business analytics, which lead to valuable insights and conclusions. It is based on the definition of a three-layers' value model of the particular e-service, which includes the main dimensions and measures of the value it generates, associated with the resources and capabilities it provides to its users (first layer – efficiency dimensions/measures), the support it provides to the users for performing various tasks and achieving various objectives (second layer – effectiveness dimensions/measures) and its impact on users' future behavior (third layer -future behavior dimensions/measures). This value model is used first for collecting e-service evaluation data from users (e.g. through an online questionnaire on the e-service website) and then for processing them. Based on these data are calculated first the average users' ratings for all value measures, dimensions and layers; this first class of business analytics allows us to identify the 'strengths' and the 'weaknesses' of the e-service at various levels of detail. Next, the impact of each first layer value dimension and measure (which is an 'independent variable' under the control of the e-service provider) on the ones of the higher levels' (which are 'dependent variables', not under the control of the e-service provider, but depending on and shaped by – at least to some extent – the abovementioned independent ones) is estimated, which is an objective indicator of its importance for the users (quantifying its impact on higher layers' value generation). In this way a second class of impact-related business analytics is calculated, which – in combination with the ones of the first class - allow a better understanding of the value generation mechanism of the e-service, and also the rational definition of improvement priorities; they allow us to identify the resources and capabilities of this e-service which are rated by the users as being of low quality and at the same time have a high impact on the generation of higher layers' value, and assign to them the highest improvement priority. The above two classes of business analytics provide a sound base for the rational continuous monitoring, improvement and optimization of the e-service, which is absolutely necessary due to the frequent enhancements and changes usually made throughout its operational life for meeting the evolving users' needs and responding to competitors' new offerings, making optimal use of the scarce human and financial resources.

The proposed methodology offers significant advantages over the existing e-services evaluation

frameworks (comprehensive reviews of them are provided by Rowley (2006) and Sumak et al (2009); a critical discussion of them is provided in 2.4). These frameworks simply propose sets of evaluation dimensions and measures, but only limited processing of them, exploiting mainly their average values over a number of users who evaluate the e-service for drawing conclusions about it. At the same time the relations among these evaluation dimensions/measures are neglected and are not exploited for drawing further conclusions; in general, the existing e-services evaluation frameworks do not proceed to the use of more advanced multi-variable statistical techniques in order to draw deeper insights and extract more knowledge from the valuable users' evaluation data, which remain underexploited. On the contrary the proposed methodology exploits both the average values of the evaluation dimensions/measures and also their relations as well, and combines them in order to provide more and deeper insights than the ones provided by existing e-services evaluation frameworks, such as a better understanding of the value generation mechanism of the e-service and a rational identification of improvement priorities. It uses a wider range of statistical techniques (calculations of averages, correlations and Cronbach Alpha values, regressions) in order to intensify knowledge extraction from e-service users' evaluation data. Furthermore, the proposed methodology provides a framework for combining, synthesizing and structuring evaluation dimensions and measures from multiple e-service evaluation frameworks.
This paper is structured in five sections. The following section 2 outlines the theoretical foundations of the proposed methodology. A description of the methodology is provided in section 3, while in section 4 a first application-validation of it is presented for an e-learning service offered by the National Technical University of Athens (NTUA) to ICT professionals. Finally, in section 5 are outlined the conclusions and future research directions.

2. Theoretical Foundations

In order to develop our methodology initially we reviewed previous research in the area of e-services evaluation, and also in the wider area of information systems (IS) evaluation. Also, we reviewed previous research in the adjacent areas of IS acceptance and success, focusing on the Technology Acceptance Models and the IS Success Models. In this section we outline some fundamental conclusions and frameworks from the above areas that have been used as theoretical foundations for building our methodology.

2.1. Information Systems Evaluation

The extensive research that has been conducted on the evaluation of IS (Hirschheim and Smithson, 1988; Willcocks, 1994; Willcocks, 1996; Willcocks and Graeser, 2001; Smithson and Hirscheim, 1998; Farbey et al, 1999; Irani, 2002; Irani et al, 2006; Gunasekaran et al, 2006; Stockdale and Standing, 2006; Irani and Love, 2008) has concluded that it is a highly complex task, because the benefits and in general the value created by most categories of IS are multidimensional and complex, both financial and non-financial and also both tangible and intangible; so the usual financial investment appraisal methods are inadequate, and a more sophisticated approach is required. Furthermore different categories of IS have different objectives and produce different types of benefits and value, so they require different types of evaluation methods and measurements. For the above reasons it is not easy to decide "what to measure" for the evaluation of an IS and "how". Smithson and Hirschheim (1998) classify the existing IS evaluation methods into two basic categories. The first category are the 'efficiency-oriented' methods, which have been influenced mainly by engineering sciences and evaluate the performance of an IS with respect to some predefined technical and functional specifications, being focused on answering the question 'is it doing things right?'. The second category consists of 'effectiveness-oriented' methods, which have been influenced mainly by management science approaches and evaluate how much an IS supports the execution of business-level tasks or the achievement of business-level objectives, being focused on answering the question 'is it doing the right things?'. Farbey et al (1999) provide a framework, named the "benefits evaluation ladder", which classifies IS according to the kind of benefits they offer in eight IS categories, and for each of them propose a different evaluation methodology. Willcocks (1994 and 1996) suggests that appropriate evaluation of IS should be performed in all stages of their life cycle, for instance at the initial feasibility study, during and at the end of the development and also during its

productive exploitation; however, he recognizes that most firms limit themselves only to the former and neglect the latter ones, and this has a negative impact on the benefits and value obtained from IS. Stockdale and Standing (2006) argue that the increasing complexity of IS, and also the emergence in the last 10 years of 'extrovert' Internet-based IS used not only inside but also outside the organization who has developed it (e.g. by customers, prospects, suppliers, etc.), makes IS evaluation even more difficult than in the past; they also recommend that IS evaluation content (i.e. what is evaluated) and process (i.e. how is the evaluation carried out) should be shaped according to the context (e.g. to the objectives of the particular IS and its main stakeholders). Irani and Love (2008) argue that in both the private and the public sector there is a 'crisis of understanding' the importance, the role and the relevance of IS evaluation throughout their life cycle; however, a robust and comprehensive IS evaluation can result in valuable organizational learning in this critical area, which can produce useful knowledge that may result in significant improvements. From this research stream it is concluded that it is not possible to develop a unique 'best' IS evaluation method appropriate for all types of IS, so for each type of IS it is necessary to formulate a different evaluation method taking into account its particular characteristics, objectives and expected benefits. However, all IS evaluation methods should deal with both the efficiency and the effectiveness perspective.

2.2. Technology Acceptance Models

Also, extensive research has been conducted on IS acceptance by users, regarding it as a major measure of IS value, aiming to identify the characteristics and factors that affect the attitude towards using an IS, the intention to use it and finally the extent of its actual usage. It is based on the Technology Acceptance Model (TAM) and its various subsequent extensions (Davis, 1989; Venkatesh and Davis, 2000; Venkatesh et al, 2003). According to the initial TAM the attitude towards using an IS, which finally determines the intention to use it and its actual use, is determined mainly by two characteristics of it: its perceived 'ease of use' (= the degree to which potential users believe that using it would require minimal effort) and its perceived 'usefulness' (= the degree to which potential users believe that using it will enhance their job performance) (Davis, 1989); each of these two factors can be elaborated into a detailed set of variables for each particular type of IS we want to study. Based on this framework extensive research has been conducted for understanding better and predicting user acceptance of various types of IS; comprehensive reviews of this research stream have been provided by Legris, Ingham and Collerette (2003), Schepers and Wetzels (2007), Turner et al (2010), Holden and Karsh (2010), and Hsiao and Yang (2010). From this research stream it is concluded that the evaluation of a particular IS type should focus on its ease of use, usefulness, actual usage and users' intention to use it in the future.

2.3. Information Systems Success Models

Another research stream that can provide useful elements to be taken into account for the evaluation of IS is the IS success models research. The most widely used of them is DeLone and McLean model of IS success (1992, 2003). It proposes seven interrelated IS success measures structured in three layers: 'information quality', 'system quality' and 'service quality' (at the first layer), which affect 'user satisfaction' and also the 'actual use' of the IS (at the second level); finally these two variables determine the 'individual impact' and the 'organizational impact' of the IS. Seddon (1997) proposed a re-specification and extension of this model, which includes the 'perceived usefulness' instead of 'actual use'. Many researchers have used and validated this model, either in its basic form or with some modifications or extensions, in order to investigate the success of various types of IS; other researchers have used the left-hand part of the model, which assume the relationships that system quality and information quality cause system use and user satisfaction (e.g. Igbaria & Tan, 1997; Garrity and Sanders, 1998; Rai, Lang and Welker, 2002; Avlonitis & Panagopoulos, 2005; Wu and Wang, 2006; Bernroider, 2008; Park, Kim and Koh, 2010). From this research stream it is concluded that IS evaluation should adopt a layered approach based on the above interrelated IS success measures (information quality, system quality, service quality, user satisfaction, actual use, perceived usefulness, individual impact and organizational impact) and on the relations among them.

2.4. e-Services Evaluation

More recently, by combining frameworks from the general IS evaluation research and the 'traditional' services quality research (such as the SERVQUAL framework (Parasuraman et al, 1988; Berry et al, 1990)), many e-service evaluation frameworks have been developed. Only a few of them are generic, providing guidance for the evaluation of e-services in general (Madu and Madu, 2002; Lu and Zhang, 2003; Fassnacht and Koese, 2006; Rowley, 2006), while most of them are more specific and focus on particular types of e-services, such as informational web sites (Loiacono et al, 2000; Aladwani and Palviab, 2002; Zeitmhal, 2002; Schubert, 2003; VanIwaarden et al, 2003; Ivory and Megraw, 2005; Kuo et al, 2005), e-shops/e-business (Turban and Gehrke, 2000; Barnes and Vidgen, 2002; Janda et al, 2002; Wolfinbarger and Gilly, 2003; Parasuraman et al, 2005; Caruana and Ewing, 2006; Behkamal et al, 2009), e-government (Barnes and Vidgen, 2003; Sukasame, 2004; Ancarani, 2005; Horan et al, 2006; Halaris et al, 2007) and e-learning (Jackson, 1998; Wang, 2003; Selim, 2003; Douglas and Van Der Vyver, 2004; Ngai et al, 2005; Shee and Wang, 2008; Ozkan and Koseler, 2009; Paechter et al, 2010). Comprehensive reviews of e-service evaluation frameworks are provided by Rowley (2006) and Sumak et al (2009). These frameworks suggest useful e-services evaluation dimensions and measures, with most of them assessing the quality of the resources and capabilities that the e-service provides to its users (oriented towards the abovementioned efficiency-oriented IS evaluation), while some others are assessing the support it provides to users for performing various tasks and achieving various objectives, or users' overall satisfaction (oriented towards the abovementioned effectiveness-oriented IS evaluation). However, the above frameworks are weak in the processing they propose for the evaluation data to be collected from the users: they propose mainly average values calculations for all evaluation measures and dimensions over all the users who evaluate the e-service for drawing conclusions about it. They do not proceed to the use of more advanced multi-variable statistical techniques in order to draw deeper insights and extract more knowledge from the valuable users' evaluation data, which remain underexploited; the relations among the proposed evaluation dimensions/measures are not exploited all for drawing more conclusions. From this research stream it is concluded that in order to evaluate an e-service it is necessary to combine efficiency and effectiveness evaluation dimensions and measures from several existing frameworks, and adapt them to the particular objectives, characteristics, resources and capabilities of the particular e-service.

3. Methodology Description

Based on the above conclusions of previous research in the areas of IS evaluation, Technology Acceptance Models (TAM), IS Success Models and e-services evaluation a methodology has been developed for transforming e-service users' evaluation data into useful business analytics that lead to valuable insights and conclusions. The basic characteristics of the methodology have been defined so that they exploit the above fundamental conclusions of previous research in order to generate more insight and knowledge on the e-service. In particular our methodology:

- has a layered structure, including evaluation dimensions and measures organized in layers, and assessing both each layer separately and also the relations among them, as recommended by the IS success models research,
- it includes both an 'efficiency' and an 'effectiveness' layer, as recommended by both the IS and the e-services evaluation research,
- and also a 'users future behavior' layer, as recommended by the TAM-related research,
- it includes both 'ease of use' and 'usefulness' evaluation dimensions and measures, as recommended by the TAM-related research,
- and it can be used during the productive exploitation of the e-service, as recommended by the IS evaluation research.

The proposed methodology is based on the estimation of a value model of the e-service, which includes the main dimensions and measures of the value it generates structured in three layers, and the relations among them. In particular, as we can see in Figure 1, the above three layers of the value model of an e-service include respectively:

(i) efficiency measures, assessing the quality of the basic resources and capabilities offered by the e-service to its users (including the quality of the information and the services it provides, and also its technical performance, as recommended by the IS success models research),
(ii) usage and effectiveness measures, assessing respectively the extent of use of the e-service and also its outcomes (e.g. to what extent the e-service assists the users for completing their tasks, achieving their objectives, offers them fun and enjoyment, or in general satisfies them),
(iii) users' future behaviour measures, assessing to what extent the e-service influences the future behaviour of its users (e.g. to what extent they intend to use the e-service again in the future, or recommend it to friends and colleagues).

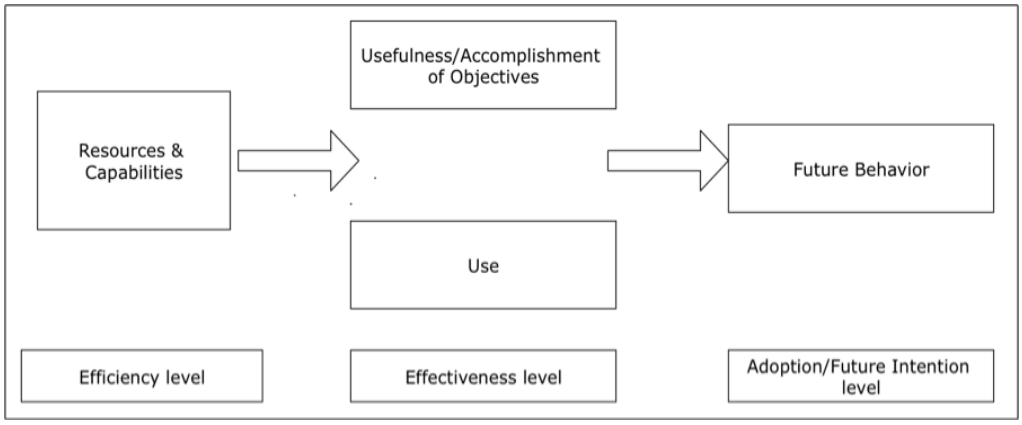

Figure 1: Structure of e-service value model

It should be noted that from these measures only the ones of first layer (efficiency measures) are 'independent variables' under the direct control of the e-service provider, who can take direct actions for improving the resources and capabilities offered by the e-service. On the contrary, the measures of the other two layers (usage, effectiveness and future behaviour measures) are 'dependent variables', since they are not under the direct control of the service provider, and depend on (i.e. are shaped by) the independent ones. While the independent variables concern 'means', the dependent variables concern the 'results/outcomes' achieved through them.
In particular, our methodology consists of the following nine stages (Figure 2):

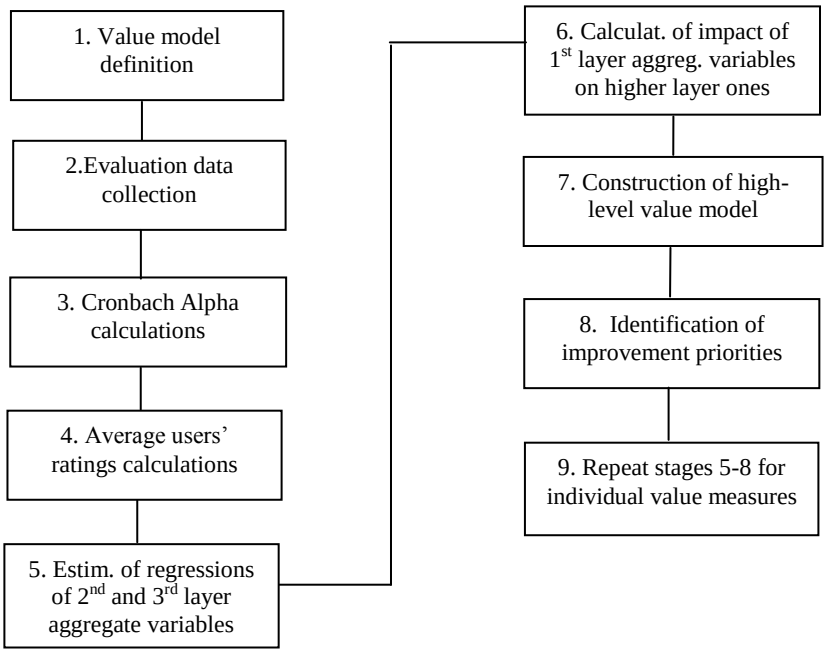

Figure 2: Methodology stages

1. Initially the value model of the e-service is defined. For this purpose the main dimensions of the value created by the e-service are identified for each layer. As mentioned above, they are usually associated with the quality of the main resources and capabilities offered by the e-service to its users (first layer), with the level of usage of it and assistance it offers to the users for completing their tasks or achieving their objectives, with the fun and enjoyment it offers them and with their overall satisfaction (second layer), and also with its influence on users' future behaviour (third layer). Then for each of these value dimensions a number of individual measures are determined. The above value dimensions and measures should be selected based on previous relevant literature (e.g. describing evaluation frameworks for this type of e-services, such as the literature discussed in 2.4), and also on the objectives, characteristics, resources and capabilities of the particular e-service.
2. Based on the above value dimensions and measures an online evaluation questionnaire is formulated (with one section for each value dimension, including one question for each measure of it), which is uploaded on the e-service website, in order to be filled by its users. In this way users' evaluation data are collected.
3. From these data initially for each value dimension the Cronbach Alpha coefficient of the individual variables corresponding to its measures is calculated, in order to assess their internal consistency. Cronbach Alpha is a well established and widely used for long time measure of internal consistency of a set of variables, which quantifies to what extent they measure different aspects of the same single uni-dimensional construct (Cronbach, 1951; Boudreau et al, 2001; Allen and Yen, 2002; Straub et al, 2004). It is defined by its creator Prof. Cronbach (Cronbach, 1951) as:

$$\alpha = (k/(k-1)) * [1- \Sigma(s^2_i)/s^2_{sum}]$$

In this formula the s^2_i ($i = 1, 2, \ldots, k$) denote the variances of the k individual variables, while the s^2_{sum} denotes the variance of the sum of all items. If the individual variables are not influenced at all by the construct then they will be uncorrelated, so the variance of the sum of them will be the same as the sum of variances of the individual variables, and Cronbach Alpha will be equal to zero. On the contrary, if all variables are measuring perfectly without any error the same construct, being all multiples of it, then the Cronbach Alpha will be equal to 1. A widely accepted and used practical 'rule of thumb' is that values of Cronbach Alpha exceeding 0.7 indicate 'acceptable' levels of internal consistency of the variables, while values exceeding 0.8 indicate 'good' levels of internal consistency (Boudreau et al, 2001; Allen and Yen, 2002; Straub et al, 2004; Kline, 2005). Therefore for each value dimension we examine whether its calculated value of Cronbach Alpha exceeds at least 0.7. If this happens then we can conclude that all its measures have acceptable internal consistency, so we can calculate an aggregate variable for it, which is equal to the average of the variables corresponding to its measures. On the contrary, if this does not happen, it means that some of the measures are not sufficiently related to this value dimension (they can be detected if for each of the individual variables is calculated the Cronbach Alpha without it, which is a standard calculation offered by all statistical packages), so they must be removed and not taken into account, or probably that this dimension should be split into two or more sub-dimensions.
4. Average users' ratings are calculated for all value measures, dimensions and layers; this provides a first class of business analytics, which allows us to identify 'strengths' and 'weaknesses' of the e-service at various levels.
5. For each aggregate variable of the second and third layer, which assesses one of the 'dependent' e-service value dimensions, we estimate a regression having it as dependent variable, and having as independent variables all the aggregate variables of the previous layers, in order to estimate to what extent this value dimension is affected by value dimensions of previous layers; this is quantified by the R^2 coefficient of the regression (Greene, 2003; Gujarati, 2003). If we find that all value dimensions of the second and third layer are affected to a large extent by the value dimensions of the previous layers (e.g. having $R^2 > 0.50$), then we can conclude that this value model is characterized by coherence among its layers, so we can proceed to the following stages. On the contrary, if one or several of the value dimensions of second and third layer are affected only to a small extent by the value dimensions of the previous layers, this indicates that probably

some important value dimensions and measures have been omitted in the previous layers, so we have to return to stage 1 and redefine the value model of the e-service.

6. For each value dimension of the first layer we estimate its impact on all value dimensions of the second and third layer. For this purpose we can use the corresponding standardised coefficients of the above regressions of stage 5. However, as clearly stated in econometric literature (e.g. Greene, 2003; Gujarati, 2003), if we have high levels of correlation between the independent variables of a regression (multi-collinearity problem), then the regression coefficients are not reliable measures of the impact of the independent variables on the dependent variable. For this reason it is better to use as measure of the impact of a first layer value dimension on a higher layer value dimension the correlation coefficient between them. In this way a second class of business analytics is calculated, which constitute objective indicators of the importance of first layer value dimensions for the users, as they quantify their impact on higher level value generation. This allows us to avoid the 'double evaluation' of each measure (i.e. asking the users to rate both the measure and its importance), which is adopted by many e-service evaluation frameworks (e.g. the 'Extended Web Assessment Method' proposed by Schubert (2003)); this allows us to have shorter questionnaires and also more reliable measures' importance assessments.

7. By combining the two classes of analytics calculated in stages 4 and 6 we can construct a high-level value model of the e-service, which visualizes the types of value generated by the e-service and the relations among them, and enables a better understanding of its value generation mechanism.

8. Finally the value dimensions of the first layer, which are the only 'independent variables' within the control of the e-service provider, are classified, based on their average ratings they receive from the users and their impacts on the value dimensions of the second and the third layer, into four groups (Figure 3): low rating – high impact, low rating – low impact, high rating – high impact and high rating – low impact. The highest priority should be assigned to the improvement of the value dimensions of the first group, which receive low ratings by the users and at the same time have a high impact on the generation of higher level value, so it is on them that we should focus our scarce human and financial resources. On the contrary, our lowest priority should be assigned to the improvement of the value dimensions of the fourth group, which already receive high ratings by the users and at the same time have a low impact on the generation of higher level value; on the contrary, we should examine whether we can move some of the human and financial resources allocated to them to the improvement of the value dimensions of the first group. Finally, medium priority should be assigned to the improvement of the value dimensions of the second and the third group.

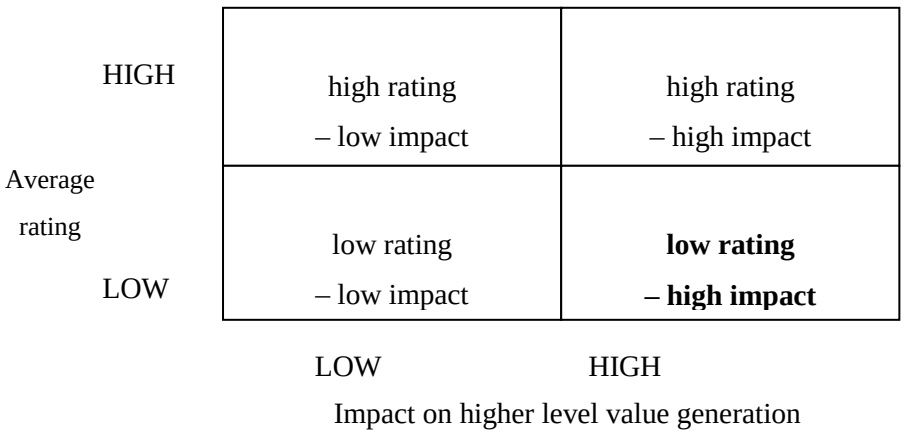

Figure 3: Classification of the independent first layer measures of resources/capabilities quality

9. Finally we repeat stages 5, 6, 7 and 8, but this time for the individual value measures/variables instead of the aggregate variables, in order to produce a similar classification of first layer value measures (which corresponding to particular characteristics of the e-service resources and

capabilities), based on their average ratings by the users and their impacts on the value measures of the second and the third layer, into four groups (Figure 2). In this way we can identify individual first layer value measures that receive low ratings by the users and at the same time have high impact on second and third layer value measures, and give to them the highest improvement priority.
This methodology provides a basis for the rational continuous monitoring, improvement and optimization of an e-service throughout its lifecycle (responding to the relevant recommendations of Willcocks (1994 and 1996)), making optimal utilization of the scarce human and financial resources. This is absolutely necessary due to the frequent enhancements and changes usually made throughout the lifecycle of an e-service for meeting the evolving users' needs and responding to competitors' new offerings. It provides e-service improvement directions and priorities, both general, at the higher level of e-service value dimensions, and also at the lower level of the value measures (i.e. specific characteristics) of it.

4. Application

A first application/validation of the proposed methodology has been made for an e-learning service offered by the National Technical University of Athens (NTUA - http://www.ntua.gr/) for ICT professionals all over Greece, who need to enhance their skills due to the continuous emergence of new technologies in this domain. At the time of our study four e-courses were offered: 'Introduction to Java', 'Introduction to Dynamic Web Design Using PHP-MySQL', 'Introduction to Web Design Using Dreamweaver 8' and 'Introduction to PC Networks and Web Technologies'. The e-learners every week access through the Internet new educational content, download it on their computers, read it, ask the responsible instructor any questions they have on it (which are accessible to all, together with instructor's answers, in the e-course space), participate in relevant e-discussions with the other e-learners and the instructor in an e-forum tool, and also do some quiz or assignment (for self-assessment purposes), which is graded by the instructor and returned. At the end of the e-course the e-learners take a 'traditional' exam in Athens, and if they pass they are awarded a certificate.

4.1. Value Model Definition

Initially the value model of this e-service was defined, based on previous literature on e-learning evaluation (Jackson, 1998; Wang, 2003; Selim, 2003; Douglas and Van Der Vyver, 2004; Ngai et al, 2005; Shee and Wang, 2008; Ozkan and Koseler, 2009; Paechter et al, 2010) and traditional learning evaluation (Bloom,1956; Marsh, 1982 and 1983; Kirkpatrick, 1983; Cashin, and Downey, 1992; Hoyt and Cashin, 1977), and also on its particular objectives, characteristics, resources and capabilities. It included its main value dimensions per layer (shown in Figure 4), and for each of them a number of value measures.

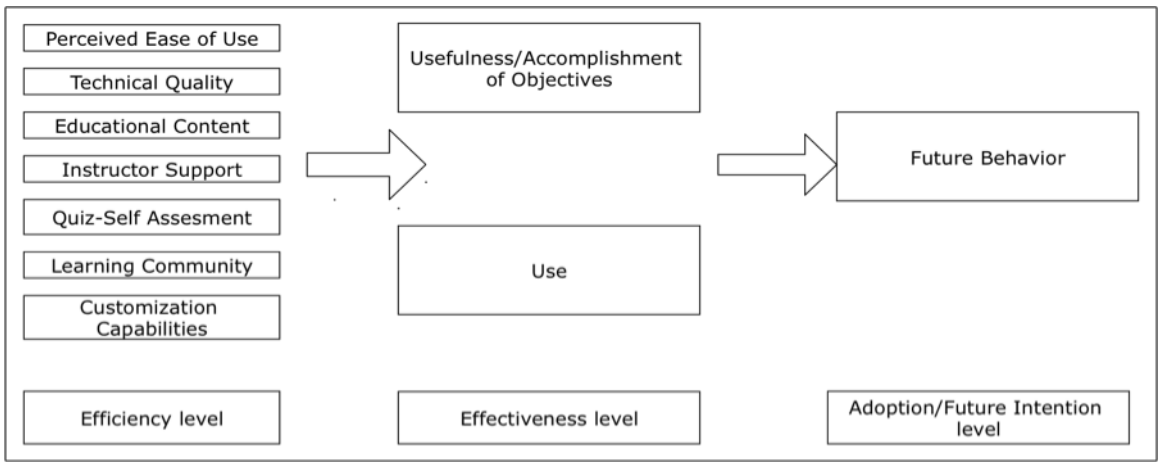

Figure 4: The value model definition of the e-learning service

From it an online evaluation questionnaire was formulated for this e-service, which is shown in the Appendix, consisting of 10 sections corresponding to the value dimensions, and 38 questions corresponding to the selected value measures; also, for each value measure we can see its conceptualization literature resources (i.e. previous literature support). Each of the questions was asking the respondent to what extent he/she agreed with a particular statement concerning one characteristic of the e-service on a seven-point Likert scale (where 1 equals to 'totally disagree' and 7 equals to 'totally agree'). We remark that for all value dimensions we have used as value measures subjective perceptions of the users. We also examined the possibility of using objective value measures as well, at least for some of the value dimensions, for which this would be meaningful and practical, e.g. for measuring the 'learning outcomes' to use the grade that each e-learner achieved in the final 'traditional' exam; also the 'use' to be measured through the exact time that each e-learner spent on the e-learning platform. However, this would necessitate non-anonymous filling of the questionnaire by the e-learners (i.e. they would have to enter their names in the questionnaires they filled, in order to link them to the grades and the times spent on the platform), which might make the students less willing to reveal their true perceptions and evaluations (e.g. be more generous in their ratings).
This questionnaire was uploaded on the website of this e-service and an e-mail with a link to it was sent to 210 e-learners, who were participating or had participated in the last 6 months in one of the abovementioned e-courses (so that it is not too long the time that has passed, and e-learners can still make reliable evaluations). All of them had a higher education degree in ICT and some professional experience; most of them were between 30 and 40 years old. The first page of the questionnaire contained some general information for the e-learners, such as the purpose of this questionnaire and instructions for filling it in; the following pages contained one section of the questionnaire each. Finally 98 persons responded and filled the questionnaire in (response rate 46.6%); the data were processed using the SPSS 15 statistical package and the results are presented below.

4.2. Cronbach Alpha Calculations

Initially for each value dimension the Cronbach Alpha coefficient of the variables corresponding to its measures was calculated, and the results are shown in Table 1. We remark that for all value dimensions Cronbach Alpha exceeds the 'acceptable' internal consistency level of 0.7 mentioned previously in section 3; furthermore, nearly for all of them (with the only exception of the 'Technical Quality') Cronbach Alpha exceeds even the 'good' internal consistency level of 0.8. Therefore we can conclude that for all our value dimensions their selected value measures are sufficiently relevant and measure different aspects of the same uni-dimensional construct. This allowed us to proceed to the calculation for each value dimension of an aggregate variable, which is equal to the average of the individual variables corresponding to its measures.

Value Dimension	Cronbach Alpha
Ease of Use	0.852
Technical Quality	0.721
Educational Content	0.935
Instructor Support	0.926
Quiz/Self-Assessment	0.802
Learning Community	0.881
Personalization	0.900
Use	0.806
Accomplishment of Educational Objectives	0.889
Future Behaviour	0.882

Table 1: Cronbach Alpha of each value dimension.

4.3. Calculations of Average Ratings for Value Measures and Dimensions

Then we calculated the average ratings for all value measures and dimensions, which are shown in Table 2 together with the corresponding standard deviations. With respect to the value dimensions of the first layer we can see that the users regard them in general as good, since the average of their average ratings is 5.99 (taking into account that 7 corresponds to 'totally agree' with the statements of the questions, and 6 corresponds to 'agree', an average of 5.99 for a value dimension means that the users find it good (but not very good)). Among them the 'Instructor Support', the 'Self-assessment/Quiz' and the 'Perceived Ease of Use' are perceived higher than good (between very good and good, with 6.14, 6.13 and 6.13 respectively), the 'Technical Quality' as good (6.02), while the 'Educational Content', the 'Learning Community' and the 'Personalization' are perceived lower than good (between good and moderately good, with 5.71, 5.73 and 5.86 respectively). With respect to the value dimensions of the second layer we can see that the users regard them in general mildly lower than good (between good and moderately good, since the average of their average ratings is 5.74). Finally, concerning the third layer value dimensions, we can see that the users have positive intentions to use this e-service in the future and recommend it to people they know (average 6.05). In a similar manner we can draw conclusions about the individual value measures. We remark that in some value dimensions the individual value measures have received similar average ratings (e.g. in the 'Learning Community'), while in some others there are considerable differences among the value measures (e.g. in the 'Learning Outcomes' we can see that users have a higher perception for the concepts and principles they have learnt (6.35) than for the knowledge synthesis abilities they have acquired (5.28)).

	Average	Std. Deviation
PERCEIVED EASE OF USE		
1.1 Ease of learning	6.11	0.86
1.2 Ease of access and navigation	6.33	0.89
1.3 Ease of communication	6.15	1.05
1.4 Ease of performing basic actions	6.07	1.11
1.5 Comprehensive and well organized GUI	5.99	1.05
Perceived Ease of Use Average (PEOU_av)	**6.13**	**0.99**
TECHNICAL QUALITY		
2.1 Availability	6.01	1.22
2.2 Response problems	5.88	1.26
2.3 Bugs	6.12	0.93
2.4 Technical support	6.07	1.05
Technical Quality Average (TQ_av)	**6.02**	**1.11**
EDUCATIONAL CONTENT		
3.1 Clarity	5.86	1.00
3.2 Structure	5.80	1.20
3.3 Quantity	5.72	1.27
3.4 Usefulness	5.72	1.20
3.5 Completeness	5.48	1.48
Educational Content Average (EDCONT_av)	**5.71**	**1.23**
INSTRUCTOR SUPPORT		
4.1 Satisfactory answers	6.06	1.17
4.2 Interaction initiation	5.82	1.42
4.3 Subject knowledge	6.51	1.04
4.4 Provision of additional information	6.17	1.43
Instructor Support Average (ISUPP_AV)	**6.14**	**1.27**
SELF-ASSESMENT/QUIZ		
5.1 Usefulness	6.44	0.71

5.2 Instructor's response	5.93	1.35
5.3 Progress self-assessment	6.04	1.13
Self-assessment/Quiz Average (QUIZ_av)	**6.13**	**1.06**
LEARNING COMMUNITY		
6.1 Communication	5.77	1.28
6.2 Team learning	5.72	1.35
6.3 Exchange of ideas	5.72	1.22
Learning Community Average (COMMUN_av)	**5.74**	**1.28**
PERSONALIZATION		
7.1 Choice of learning pace	5.90	1.27
7.2 Choice of learning manner	5.93	1.09
7.3 Focus on personal interests	5.85	1.19
7.4 Learning process customization	5.79	1.23
Personalization Average (PERSON_av)	**5.86**	**1.19**
Average of First Layer Value Dimensions	**5.99**	
LEARNING OUTCOMES		
8.1 Concepts/principles learned	6.35	0.74
8.2 Methods/technologies learned	6.17	0.89
8.3 Ability of practical application	5.75	1.17
8.4 Ability of analysis	5.52	1.31
8.5 Ability of synthesis	5.28	1.38
Learning Outcomes Average (LOUT_av)	**5.81**	**1.10**
USE		
9.1 Time of study	5.62	1.25
9.2 Use of communication tools	5.62	1.29
9.3 Use of self-evaluation tools	5.75	1.14
Use Average (USE_av)	**5.66**	**1.23**
Average of Second Layer Value Dimensions	**5.73**	
INTENTION TO USE		
10.1 Recommendation to others	6.06	1.31
10.2 Future participation	6.04	1.34
Intention to Use Average (INT_av)	**6.05**	**1.28**

Table 2: Average ratings and standard deviations for all value measures and dimensions

4.4. Regressions Estimation

As a next step we examined in order to what extent the value dimensions of the second and third layer are affected by the value dimensions of the first layer. For this purpose initially we estimated two regression models having as dependent variables the two value dimensions of the second layer respectively (aggregate variables LOUT_av - model_1 - and USE_av - model_2) and as independent variables the seven value dimensions of the first layer (aggregate variables PEOU_av, TQ_av, EDCONT_av, ISUPP_AV, QUIZ_av, COMMUN_av and PERSON_av). Also, we estimated one regression model having as dependent variable the value dimension of the third layer (aggregate variable INT_av) and as independent variables the two value dimensions of the second layer (model_3), and finally another similar regression model having as additional independent variables the seven value dimensions of the first layer (so nine independent variables in total - model_4). In Table 3 are shown the R^2 coefficients of these four regression models.

We can see that the R^2 coefficients of model_1 and model_2 are 0.617 and 0.640 respectively, indicating that both second layer value dimensions (use and learning outcomes) are affected to a large extent by the ones of the first layer. On the contrary the R^2 coefficient of model_3 third is 0.347, which is much lower, indicating that the third layer value dimension (associated with future behavior) is affected to a smaller extent by the ones of the second layer. However, the last

model (model 4) has a much higher R^2 coefficient 0.787, which indicates that both first and second layer value dimensions affect to a large extent the one of the third layer; this means that first layer value dimensions affect users' future behavior both directly and indirectly (through the second layer value dimensions). From the above results we can conclude that this value model is characterized by high coherence among its layers.

Regression Models	R^2
model_1	0.617
model_2	0.640
model_3	0.347
model_4	0.787

Table 3: Regression models of second and third layer value dimensions

4.5. Correlation Analysis of Value Dimensions

After having confirmed the consistency of our value model, the next step was to investigate the impact of the first layer value dimensions on the ones of the second and the third layer. For this purpose we calculated for each of the first layer aggregate variables the correlation coefficients with the three aggregate variables of the second and the third layer, and also their average. The results are shown in Table 4 (all correlations are statistically significant). We remark that the first layer value dimensions of 'Instructor Support', 'Self-assessment/Quiz', 'Educational Content' and 'Personalization' have the highest average correlations with the higher layers' value dimensions (0.653, 0.623, 0.562 and 0.524, respectively). This indicates that those four elements of the e-service have the strongest impact on higher level value generation. Furthermore, Table 4 shows that the 'Use' of the e-service is mainly influenced by 'Instructor Support' (0.551), 'Self-assessment/Quiz' capabilities (0.545) and 'Learning Community' (0.544). On the other hand, the extent of 'Learning Outcomes' is mainly influenced by the 'Educational Content' (0.670), 'Self-assessment/Quiz' capabilities (0.666) and 'Personalization' Capabilities (0.659).

	USE_av	LOUT_av	INT_av	AVERAGE
PEOU_av	0.412	0.380	0.308	0.366
TQ_av	0.273	0.429	0.325	0.342
EDCONT_av	0.446	0.670	0.571	0.562
ISUPP_av	0.551	0.560	0.849	0.653
QUIZ_av	0.545	0.666	0.659	0.623
COMMUN_av	0.544	0.460	0.365	0.456
PERSON_av	0.434	0.659	0.480	0.524

Table 4: Correlations of first layer value dimensions with second and third layer ones

4.6. High-level Value Model

By combining the results of 4.3 and 4.5 the high-level value flow model of this e-service has been constructed, which is shown in Figure 5. It provides a compact visualization of the main dimensions/types of value generated by this e-service (quantified through the corresponding average users' ratings) and the relations among them (quantified through the corresponding correlation coefficients). This enables a better understanding of the value generation mechanism of this e-service, as it shows how value of one layer is transformed to value of higher layers, and also the origins of higher layers' value.

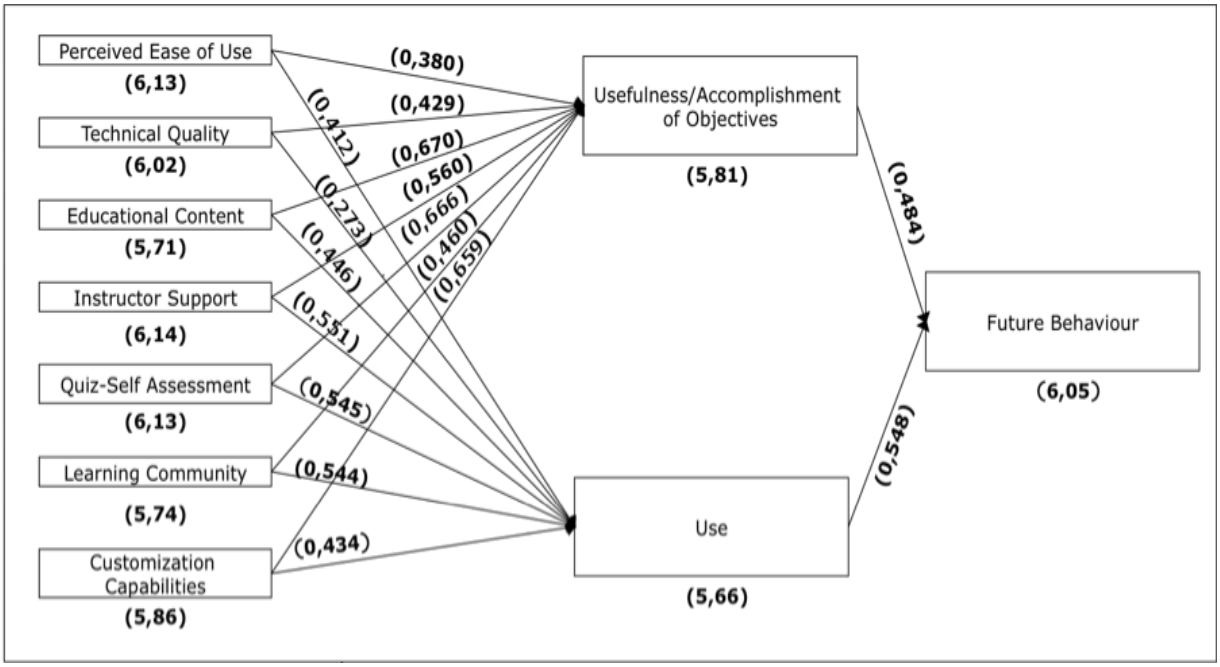

Figure 5: The high-level value model of the e-learning service

4.7. Correlation Analysis of Value Measures

Having a first picture on the extent of influence of the first layer value dimensions on the ones of the second and third layers, we then proceeded to constructing a more detailed one using the individual value measures (quantifying particular e-service characteristics). For this purpose, for every individual variable of the first layer (28 variables in total) we calculated its correlations with all individual variables of the second layer (8 variables) and the third layer (2 variables), and also their average, which is shown in Table 5. For calculating this average only the statistically significant correlations have been taken into account, while the non-significant ones were regarded as zero; note that for variable 2.1 (availability) the average correlation is 0 because all its correlations with the variables of the second and third layer to its are non-significant.

	Value dimension	Value measure	Average Correlation
1.1	Perceived Ease of Use	Ease of learning	0.255
1.2		Ease of access and navigation	0.290
1.3		Ease of communication	0.143
1.4		Ease of system basic functions	0.085
1.5		Comprehensive and well organ. GUI	0.166
2.1	Technical Quality	Availability	0.000
2.2		Response problems	0.270
2.3		Bugs	0.165
2.4		Technical Support	0.240
3.1	Educational Content	Clarity	0.362
3.2		Structure	0.447
3.3		Quantity	0.460
3.4		Usefulness	0.534

3.5		Completeness	0.422
4.1	Instructor Support	Satisfactory answers	0.472
4.2		Interaction initiation	0.527
4.3		Subject knowledge	0.417
4.4		Additional information provision	0.552
5.1	Self-Assessment/Quiz	Quiz usefulness	0.540
5.2		Instructor's response	0.544
5.3		Progress self-assessment	0.467
6.1	Learning Community	Communication	0.256
6.2		Team learning	0.428
6.3		Exchange of ideas	0.263
7.1	Personalization	Choice of learning pace	0.338
7.2		Choice of learning manner	0.351
7.3		Focus on personal interests	0.525
7.4		Learning process customization	0.417

Table 5: Average correlations of first layer value measures with the ones of second and third layer

From the above results it is concluded that the first layer value measures (characteristics) that seem to be more correlated with the higher layers' ones are the provision of additional information by the instructor to the e-learners about their particular needs (0.552) (since the e-learners are already ICT professionals, so, beyond acquiring general skills and knowledge on the e-course subject, they also want to focus on their particular needs), instructor's response to questions about the assignments (0.544), self-assessment/quiz usefulness (0.540) and educational content usefulness (in accordance with personal educational needs) (0.534). This indicates that these e-service characteristics have the strongest impact on higher layers' value generation. We remark that all of them belong to first layer value dimensions that have been found previously in 4.5 to be strongly correlated to the higher layers' ones (Instructor Support, Self-assessment/Quiz and Educational Content respectively). Also, by combining the results of 4.3 and 4.7 the low-level value model of this e-service has been constructed, providing a more detailed visualization of the value generation mechanism of this e-service than the high-level value model shown in Figure 5.

4.8. Definition of Improvement Priorities

Finally, we defined improvement priorities for this e-service, both at the higher level of value dimensions and at the lower level of value measures (i.e. particular characteristics). For this purpose initially based on the results of 4.3 we classified the seven first layer value dimensions into two groups according to their average ratings by the users: in the first group were classified the ones below the average of the lowest rated (Educational Content: 5.71) and the highest rated (Self-assessment/Quiz: 6.14) ones (so (5.71+6.14)/2 = 5.92), and in the second group the ones above this average (Table 6). Then based on the results of 4.5 we classified them similarly into two groups according to their average correlation with the second and third layers' value dimensions (Table 7).

5.71	5.92	6.14
Educational Content, Learning Community, Personalization		Technical Quality, Perceived Ease of Use, Instructor Support, Self-assessment/Quiz

Table 6: Classification of first layer value dimensions according to their average ratings by users

0.342	0.497	0.653
Technical Quality, Perceived Ease of Use, Learning Community		Personalization, Educational Content, Self-assessment/Quiz, Instructor Support

Table 7: Classification of first layer value dimensions according to their average correlation with the second and third layers' value dimensions

From these two classifications we can conclude that our highest priority should be assigned to the improvement of the Educational Content and the Personalization Capabilities, since they received low ratings from the users, and at the same time they have high impact on higher layers' value generation.

In a similar manner we defined improvement priorities at the level of individual value measures (characteristics). Based on the results of 4.3 we classified the 28 first layer value measures into two groups according to their average ratings by the users (Table 8). Aldo, based on the results of 4.6, we classified them similarly into two groups according to their average correlation with the second and third layers' value measures (Table 9).

5.48	5.99	6.51
2.2, 3.1, 3.2, 3.3, 3.4, 3.5, 4.2, 5.2, 6.1, 6.2, 6.3, 7.1, 7.2, 7.3, 7.4		1.1, 1.2, 1.3, 1.4, 1.5, 2.3, 2.4, 4.1, 4.3, 4.4, 5.1, 5.3

Table 8: Classification of first layer value measures according to their average ratings by users

0	0.276	0.552
1.1, 1.3, 1.4, 1.5, 2.1, 2.2, 2.3, 2.4, 6.1, 6.3		1.2, 3.1, 3.2, 3.3, 3.4, 3.5, 4.1, 4.2, 4.3, 4.4, 5.1, 5.2, 5.3, 6.2, 7.1, 7.2 ,7.3, 7.4

Table 9: Classification of first layer value measures according to their average correlation with the second and third layers' value measures

From these two classifications we can identify the value measures (i.e. individual e-service characteristics) to which the highest improvement priority should be assigned, as the intersection of the subset of the measures that received low ratings from the users, and the subset of those having higher average correlations with the ones of the second and third layer; they are shown below in Table 10.

3.1	Content Clarity
3.2	Content Structure
3.3	Content Quantity
3.4	Content Usefulness
3.5	Content Completeness
4.2	Interaction initiation by the instructor
5.2	Instructor response to assignments
6.2	Team learning
7.1	Choice of learning pace
7.2	Choice of the way of learning
7.3	Focus on issues of interest
7.4	Learning process customization

Table 10: Value measures (characteristics) to be assigned the highest improvement priority

We remark that 3.1-3.5 and 7.1-7.4 belong to the value dimensions 'Educational content' and 'Personalization', which have been identified previously as having highest priority for improvement. Also, the analysis at the level of the individual value measures revealed three additional ones that should be assigned the highest priority for improvement (interaction initiation by the instructor (4.2), instructor response to e-learners assignments (5.2) and team learning (6.2)), which do not belong to the above two value dimensions of top improvement priority.

5. Conclusions

As mentioned in the introduction a big number of e-services have been developed and are currently used by individuals and organizations, such as e-business, e-banking, e-government and e-learning services; however their usage and quality are below expectations. Since this is a new area, a lot of learning and improvement is required in order to progress towards higher levels of maturity. In this direction many organizations have started analyzing the enormous amounts of data of their web log files in order to draw conclusions that will assist them in identifying and implementing necessary technical and business improvements. This need leads to the gradual development of the 'web analytics' industry, which includes an increasing number of firms offering software and services for the analysis of weblog data about the online activities of websites' visitors, and the production of useful reports that enable a better understanding of them and also provide guidance for improvement and optimization. The progress towards these directions necessitates the development of advanced methodologies, which are founded on and exploit conclusions of the rich previous relevant IS research, and build on them in order to achieve a more sophisticated analysis of various types of e-service users' activity and evaluation data, so that more insight and knowledge can be extracted from them. Developments in this area will be very useful both for the web analytics industry and for the organizations offering various types of e-services, and will contribute to achieving higher maturity and quality in the e-services.

This paper contributes in this direction by presenting a methodology for transforming the large amounts of evaluation data collected in e-services websites into business analytics, which lead to highly useful insights and conclusions. The proposed methodology is based on the definition of a value model of the e-service, which includes its main value dimensions, and for each of them its main value measures, structured in three layers focusing on e-service efficiency, effectiveness and the users' future behavior respectively. This value model guides both the collection of e-service evaluation data and their processing. Our methodology is founded on and uses elements from well established theoretical frameworks developed in previous research in the areas of IS evaluation, Technology Acceptance Models (TAM), IS Success Models and e-services. A first application/validation of it has been presented for an e-learning service provided by the National Technical University of Athens (NTUA) to ICT professionals, and has provided evidence that it is practically applicable with a reasonable effort and it provides interesting insights, conclusions and improvement directions.

The proposed methodology offers significant advantages over the existing e-services evaluation frameworks, which simply propose sets of evaluation dimensions and measures, but only limited processing of them, exploiting mainly their average values over a number of users who evaluate the e-service for drawing conclusions about it. On the contrary the proposed methodology exploits both the average values of the evaluation dimensions/measures and also the relations among them. By combining these two classes of business analytics it can provide more and deeper insights than the ones provided by existing e-services evaluation frameworks; it allows not only the identification of strengths and weaknesses of the particular e-service, but also a better understanding of its value generation mechanism and a rational identification of improvement priorities. It uses a wider range of statistical techniques (calculations of averages, correlations and Cronbach Alpha values, regression) in order to intensify knowledge extraction from e-service users' evaluation data.

The research presented in this paper has interesting implications for research and practice. With respect to research it proposes a widely applicable approach for defining structured multi-layer e-services value models, by synthesizing views and elements from various frameworks developed in previous research, and then for estimating them based on users' evaluation data, which can be

useful in future e-services research. This approach allows the calculation of a 'new generation' of highly useful business analytics, which combine information from several e-service value measures, and provide new highly useful insights in the e-services. In this sense it enables a more structured and comprehensive evaluation of e-services, which includes a detailed assessment of the various types of value they generate and the relations among them. With respect to e-services practice it provides a sound base for the rational continuous monitoring, improvement and optimization of an e-service, making optimal use of scarce human and financial resources; it allows the identification of its strengths, weaknesses and improvement priorities. The proposed methodology is characterized by wide applicability to any type of e-services, e.g. to e-business, e-banking, e-government and e-learning services. Each of these different types of services has different kinds of objectives and characteristics, offers different kinds of resources and capabilities to its users, and supports the achievement of different kinds of tasks and objectives. Therefore for each e-services type it is necessary to define different kinds of value dimensions and measures in the three layers of the value model, which reflect its specificity. Especially in the efficiency layer it is necessary to define value dimensions and measures that focus on the quality of the particular resources and capabilities it offers to the users; also, in the effectiveness layer it is necessary to define value dimensions and measures that focus on the particular tasks or objectives it aims to support. For this value model adaptation very useful can be the conclusions of previous relevant literature on the benefits and evaluation of this particular type of e-services. Furthermore, the proposed methodology can also be used for e-services for which evaluation data have already been collected, without being based on a systematically developed value model of the e-service. In such cases we can divide the evaluation questions (= value measures) into two categories, which assess 'means' (e.g. resources and capabilities offered to users) and 'outcomes' (i.e. extent of assistance offered to users for executing some tasks or achieving some objectives) respectively, and then follow the stages of the methodology described in section 3. This is going to provide a useful overall picture of the relations between means and outcomes; also, it will identify the means that should be assigned the highest improvement priority, based on their ratings by the users and their correlations with the outcomes.

A limitation of this study is that the proposed methodology has been applied, elaborated and validated only in one type of e-services (e-learning); also, for collecting evaluation data has been used a group of ICT professionals having high level of education and computer skills. Therefore further research is required for elaborating and validating the proposed methodology in other types of e-services as well, and collecting evaluation data from users of various levels of education and computer skills. Another limitation is that the for all value dimensions we have used as value measures subjective perceptions of the users; it would be interesting if we could use objective value measures as well, at least for some of the value dimensions, for which this would be meaningful and practical (e.g. for measuring the 'learning outcomes' we could use the grade that each e-learner achieved in the final 'traditional' exam; also, the 'use' could be measured through the exact time that each e-learner spent on the e-learning platform). Finally, it would be interesting to investigate the use of other sophisticated statistical methods for analyzing e-service users' evaluation data and calculating new types of business analytics providing additional useful insights and conclusions.

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APPENDIX:

Questionnaire for the e-learning service evaluation and conceptualization literature resources

	Factors	Conceptualization Resources
	1. EASE OF USE	
1.1	It was easy to learn the basic functionalities of the e-learning system.	Shee and Wang (2008), Selim (2005)
1.2	It was easy to access the educational content and navigate in it.	Ozkan and Koseler (2009), Soong et al (2001), Selim (2005)
1.3	It was easy to contact the instructor and other colleagues of mine, by using e-mail, forum, etc.	Shee and Wang (2008), Selim (2005)
1.4	It was easy to perform the necessary actions in a direct way and a small nymber of steps.	Davis (1989), Volery and Lord (2000), Soong et al (2001), Selim (2005)
1.5	The interfaces of the e-learning system were clear, comprehensive and well-organized.	Volery and Lord (2000), Soong et al (2001), Selim (2005)
	2. TECHNICAL QUALITY	
2.1	The e-learning system and course were fully available without any interruption problems.	ISO 9126, Fresen and Boyd (2005), Ozkan and Koseler (2009)
2.2	I didn't face any response problems.	ISO 9126, Fresen and Boyd (2005)
2.3	I didn't realize any bugs while using the e-learning system.	Bouras and Konidaris (2003), Fresen and Boyd (2005), Ozkan and Koseler (2009)
2.4	I had a very good technical support while using the e-learning system whenever neccessary.	Bouras and Konidaris (2003), Fresen and Boyd (2005)
	3. EDUCATIONAL CONTENT	
3.1	The electronic educational content was clear and comprehensive.	Govindasamy (2002), Turban and Gehrke (2000), Janda et al (2002), Shee and Wang (2008), Fresen and Boyd (2005)
3.2	The electronic educational content was well organized and structured.	Selim (2005), Govindasamy (2002), Shee and Wang(2008)
3.3	The quantity of the content (basic texts, articles, links, multimedia material) was sufficient and satisfactory.	Govindasamy, 2002, Turban and Gehrke (2000),Shee and Wang (2008), Holsapple and Lee-Post (2006)
3.4	The electronic educational content was useful and according to my personal educational needs.	Selim (2005), Shee and Wang (2008)
3.5	The electronic educational content was complete and up-to-date.	Govindasamy, 2002,Turban and Gehrke (2000),Janda et al (2002),Shee and Wang, 2008,Holsapple and Lee-Post (2006)
	4. INSTRUCTOR SUPPORT	
4.1	The instructor responded to my questions about the course content in a timely and understandable manner.	Hoyt and Cashin (1977), Selim (2005), Ozkan and Koseler (2009)
4.2	The instructor stimulated interaction among students through e-mail forum, chat, etc.	Soong et al (2001), Selim (2005), Paechter et al (2010)
4.3	The instructor had a good knowledge and background of the course subject.	
4.4	The instructor provided me with additional information according to my particular interests.	Hoyt and Cashin (1977), Cashin and Downey (1992), Soong et al (2001), Selim (2005), Paechter et al. (2010)
	5. QUIZ/SELF-ASSESMENT	
5.1	The assignments during the e-course helped me to better comprehend its content.	Paechter et al. (2010), Marsh (1982), Marsh (1987)
5.2	Instructor's response in questions regarding assignments helped me to understand my mistakes and weaknesses.	Fresen and Boyd (2005), Paechter et al. (2010)
5.3	The quiz enabled me to realize the level of my progress and to identify my weaknesses.	Shee and Wang (2008), Fresen and Boyd (2005), Paechter et al. (2010)
	6. ELECTRONIC LEARNING COMMUNITY	
6.1	The e-learning system made it easy for me to interact with my colleagues (e.g. through e-mail, forums, chats, etc.)	Volery and Lord (2000), Soong et al. (2001), Selim (2005), Shee and Wang (2008), Fresen and Boyd (2005)
6.2	Overall, the e-learning system made me feel a part of a community, sharing common goals with other people.	Selim (2005), Shee and Wang (2008), Fresen and Boyd (2005)
6.3	I had communication and exchanged ideas and opinions with my colleagues and the instructor during the e-course.	Volery and Lord (2000), Soong et al (2001), Selim (2005), Shee and Wang (2008), Piccoli et al (2001), Fresen and Boyd (2005)
	7. CUSTOMIZATION	
7.1	The system enabled me to choose the pace of the e-learning process according to my own style and needs.	Paechter et al (2010), Hamid (2001), Shee and Wang (2008)
7.2	The system enabled me to choose the manner of learning according to my own style and needs.	Paechter et al (2010), Hamid (2001), Shee and Wang (2008)
7.3	The system enabled me to focus on the issues I am really interested in and gain a deeper knowledge.	Wang (2003), Paechter et al (2010), Shee and Wang (2008)
7.4	The system allowed me to personalize and set up the e-learning process according to my needs and abilities.	Ozkan and Koseler (2009), Shee and Wang (2008), Wang (2003)
	8. ACEO	
8.1	I have learned important concepts and principles regarding this e-course.	Hoyt and Cashin (1977), Cashin and Downey (1992), Bloom (1956), Kirkpatrick (1983)
8.2	I have learned important methods and technologies related to the subject of this e-course	Hoyt and Cashin (1977), Cashin and Downey (1992), Bloom (1956), Kirkpatrick (1983)
8.3	In this e-course I have gained the ability of practically applying my knowledge.	Hoyt and Cashin (1977), Cashin and Downey (1992), Bloom (1956), Kirkpatrick (1983)
8.4	In this e-course I have gained the ability of analyzing complex problems into smaller parts.	Hoyt and Cashin (1977), Cashin and Downey (1992), Bloom (1956), Kirkpatrick (1983)
8.5	In this e-course I have gained the ability of synthesizing knowledge from facts, ideas and data.	Hoyt and Cashin (1977), Cashin and Downey (1992), Bloom (1956), Kirkpatrick (1983), Jackson (1998)
	9. USE	
9.1	I have dedicated a lot of time studying the content of the e-course	Davis, (1989), Selim (2002), Delone and McLean (2003)
9.2	I have extensively used the tools provided to communicate and interact with the Instructor and colleagues.	Davis, (1989), Selim (2002), Delone and McLean (2003)
9.3	I have dedicated a lot of time doing the assignment and participating in the quiz.	Davis, (1989), Selim (2002), Delone and McLean (2003)
	10. FUTURE USAGE BEHAVIOR	
10.1	I would recommend this e-learning course to someone I know and would be interested in the same subject.	Winer (2001), Saade and Bahli (2005), Ngai et al (2005), Chiu et. al (2005)
10.2	I would be interested in participating in another e-learning course offered by the same institution.	Winer (2001), Bhatarchejee (2001), Saade and Bahli (2005), Ngai et al (2005,) Chiu et al (2005)